Determination of Maturity Indices of Papaya Fruits Cv Red Lady

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Abstract

Maturity indices of papaya fruits vary with variety and growing environment. During maturation, papaya varieties differ in terms of skin color, pulp color, fruit firmness, and Total Soluble Solid (TSS). Although Red Lady is the most popular papaya cultivar in Nepal, its maturity indices have yet to be investigated. Therefore an experiment was conducted at the farmer's field of Kalika Municipality of Chitwan district to identify the maturity indices of the Red Lady variety of papaya. Both destructive and non-destructive methods were used for determining the maturity indices, among non-destructive methods; visual observations, and colorimeter reading were recorded. Based on visual observation, six maturity indices were identified as MS1, MS2, MS3, MS4, MS5, and MS6. Colorimeter readings of those six stages were recorded by using a digital colorimeter. The l* value which represents the brightness of fruits ranges from 30.7-53.1 in MS1 to MS6. Similarly, a* representing the degree of greenness ranges from -15.5 in MS1 to 4.6 in MS6. Likewise, b* indicating yellowness varies greatly with the minimum value in MS1 (15.0) and the maximum value (35.1) in MS6. In destructive methods, fruit firmness and TSS were measured by using a penetrometer and refractometer respectively. The fruit firmness of different stages of maturity gradually decreases from 11.2 kg/cm2 in MS1 to 1.1 kg/cm2 in MS6 while the TSS of different maturity stages greatly increases from 4.2°Brix in MS2 to 12.48°Brix in MS6.

Keywords: Colorimeter, Firmness, Maturity, and Stages

Introduction

Maturity refers to the stage where a commodity reaches to sufficient stage of development such that its quality will be at least minimum acceptable to the consumer even after harvesting. An appropriate stage of maturity is of paramount importance for attaining desirable quality, flavor, nutritive value, and shelf life. The quality of harvested fruit develops during its growth when it is attached to the plant. Once the produce is harvested or detached from the plant, its quality can't be improved but only can be maintained at its best and any mistake made during harvest is reflected in the produce (Kader et al, 1999). Therefore harvesting horticultural produce at the proper stage of maturity is very crucial. Maturity may be able to identify the right time for harvesting (Prasad et al, 2018). Maturity indices are the sign or indications that a commodity is ready to harvest. The identification of the maturity stages of fruits aids in longer

shelf life with improved quality facilitating long-distance marketing (Babu et al, 2017).

During maturation, papaya varieties differ in terms of changes in skin color, pulp color, fruit firmness, and TSS (Basulto, 2009). A wide range of physical features (Size, shape, and surface characteristics) is used to assess the maturity of commodities. Maturity indices of papaya fruits vary with variety and growing environment. Generally, the Yellow color in the fruit skin has been traditionally used as a harvest index criterion (Eva et. al, 2017). Harvesting the fruit before optimum maturity fails to develop good eating quality. The delayed harvesting improves fruit quality, but limits shelf life and increases susceptibility to pests and diseases. So, the time of harvesting should therefore be determined by considering all these factors (Azene et. al). Chaudhary et al., 2012 identified Pusa Dwarf and Farm Selection-1 as the most preferred genotypes due to excellent fruit-bearing, dwarfness, and yield but Red Lady was preferred due to its earliness, uniform ripening, good taste, and hard skin in inner terai and tar area. Originally from Taiwan, Red lady was introduced in Nepal from India which is an early high-yielding variety having red, hard, and thick flesh and has become a commercially prominent cultivar. Despite its importance, research on the identification of a suitable maturity stage for papaya fruit in the context of Nepal has not been done yet.

Materials and Methods

The experiment was conducted at papaya farm of Kalika Municipality of Chitwan district during the month of November 2021. Papaya fruits cv Red Lady with uniform shape and size of different maturity stages namely MS0, MS1, MS2, MS3, MS4, MS5 and MS6 as suggested by (Basulto et al 2009) were harvested by hand picking. The visual characters mainly skin color, flesh color and seed color were recorded. The visual characteristics reading were recorded from five fruits of each stages of maturity which were further replicated three times; therefore altogether there were fifteen reading from each maturity stages. After recording the visual characteristics of different maturity stages, color readings were also recorded from same sample fruits. Color reading was recorded by using a digital hand held Chroma Meter (CR-200 Chroma Meter) manufactured by Konica Minolta Sensing. Data obtained from Chroma Meter were represented as L*(degree of brightness), a* (degree of redness or greenness) and b* (degree of yellowness and blueness) values of Cielab scale as described by McGuire, (1992). Three Skin color readings were recorded from stalk end, middle and blossom end of the fruits, altogether there were 9 readings from one sample fruits. The total soluble solids (TSS) were determined from the destructive sample after the peel, placenta, and seeds were removed, the flesh of papaya was cut into small pieces and the pulp was homogenized in a laboratory blender. Two drops of clear juices were placed on the prism of a digital handheld refractometer (Atago, model Hybrid PAL-BXIACID F5). The firmness of the fruit was measured manually using a digital penetrometer (Lutron model FR-5120). Each fruit was dissected vertically, each half placed on a table with the cut area facing up, and the plunger vertically pressed into the flesh along the cut surface. The average readings (kg/cm2) were recorded for firmness determination. The statistical analysis of collected data was done by using GenStat (18th version) and a comparison of the treatment means was made by Duncan Multiple Range Test (DMRT).

Results

1. Visual Characteristics

The result of the experiment shows a significant difference among 6 different maturity stages in terms of visual characteristics. Immature papayas have dark green skin color, pulp completely white and seeds were fully developed

but white in color. Immature fruits also have large amount of latex. With advancement of maturity, the skin color also changes from green to yellow with few degree of yellowness in MS1 to fully yellow in MS6. External and internal characteristics of the sampled Red Lady fruit at each maturity stage are shown in Table 1.

Table 1: Visual characteristics of Red Lady papaya at different maturity stages

Maturity Stage	Fruit color	Pulp color	Visual Characteristics	Remarks
MS0			Dark green skin, pulp completely white, seeds well-formed but white in color, very hard flesh, contain large amounts of latex.	Immature, not ready for harvest
MS1			Light green skin, pulp whitish with traces of red color, contains latex, flesh still hard	Mature but not suitable for harvest
MS2			Green with yellow stripe, pulp exhibits some areas with red color, flesh little bit soft	Suitable for distant market
MS3			Skin color more green than yellow, pulp almost completely red in color, sweet in taste	Suitable for distant market
MS4			Skin color more yellow than green, pulp completely red, flesh soft, sweetness increases	Suitable for local market
MS5			Skin color yellow with some green traces, pulp completely red, flesh soft, and appropriate for consumption	Suitable for local market
MS6			Fully yellow-reddish, pulp very soft, sweetest	Suitable for instant consumption and processing

2. L*value

The figure shows the pattern of brightness (L* value) of different maturity stages of Red Lady variety of papaya. The L* value represents the luminosity or brightness which corresponds to the change of values from 0 to 100 (from dark to light). During ripening, luminosity (L*) of blossom end increased from 32.3 (green/immature) fruit to 63.6 (MS6). Similarly, L* value also increases in middle and stalk end from 30.7 to 56.8 and 29.3 to 58.3 respectively (figure 1). The highest color changes are observed when fruit are at advanced maturity stage. In general, the loss of chlorophyll makes yellow and red tones more evident, where carotenoids and other pigments are responsible for these colors (Sancho et. al, 2010) and it was observed that papaya skin showed significant statistical differences between the MS1 and MS6 stage. Nevertheless, this change was minimum in MS3 and MS4 at blossom end than other stage (figure 1). A similar pattern was observed in tomatoes (Marquez and Cortes, 2007) and apples (Rizzolo et al., 2006), where luminosity was higher in ripened fruit. However, Santamaría, 2009 in golden papaya found that the L* value significantly increases from MS2 to MS4 and then decreased slightly in stages 5 and 6. This might be due to differences in variety.

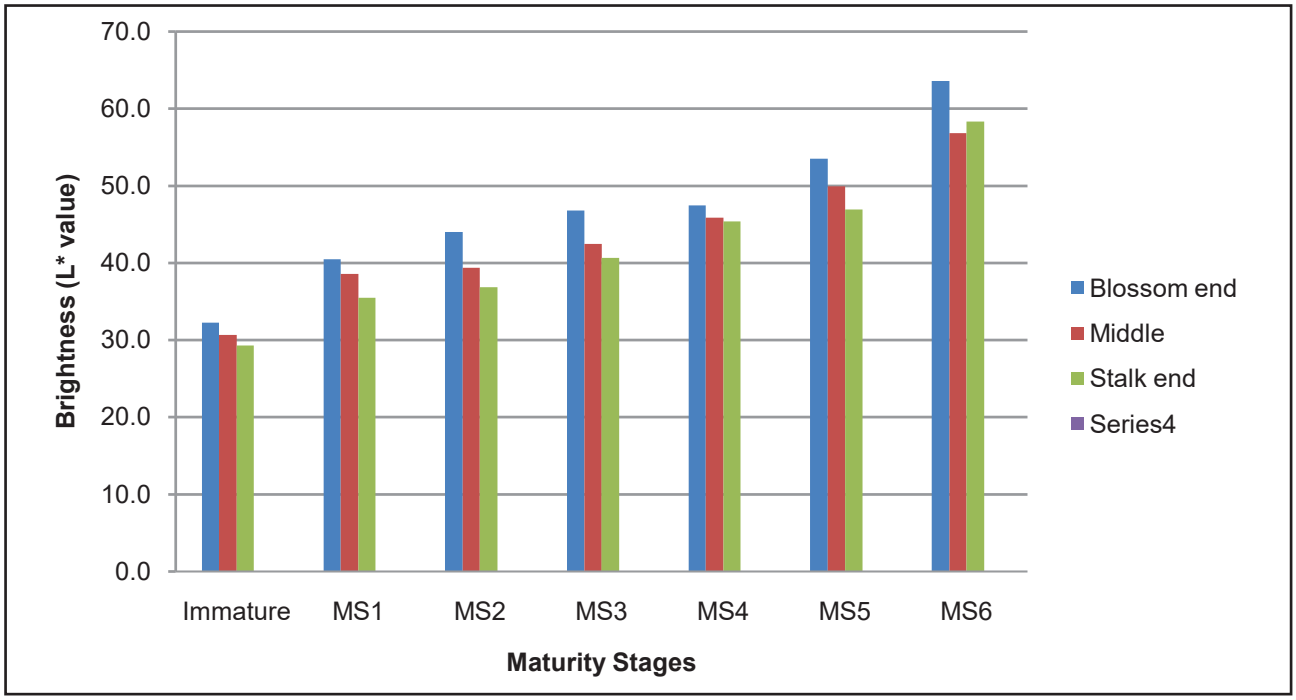

Figure 1: Brightness (L* value) of different maturity stages of Red Lady variety of papaya, 2020

3. a* value

Skin a* values presented distinct changes linked to maturity stage. Values were negative (green color) in green fruit and MS1 to MS5 except positive for blossom end in MS5 and then positive (red color) in MS6 (Figure 2). This makes the skin a* value a useful indicator in the later maturity stages, although it is not very useful in defining the early maturity stages, since there is little distinction in a* values among immature fruit, MS1 and MS2 fruit. The a* value showed the most visible change in late maturity stages. No major changes were observed when fruits were still predominately green or red (light yellow to yellow), but there was a sharp increase of value after MS5 at blossom end with a* value changing from negative (green color) to positive (red color) which indicates the loss of chlorophyll and the biosynthesis of carotenoids in the fruit (Yahia and Ornelas-Paz, 2009).

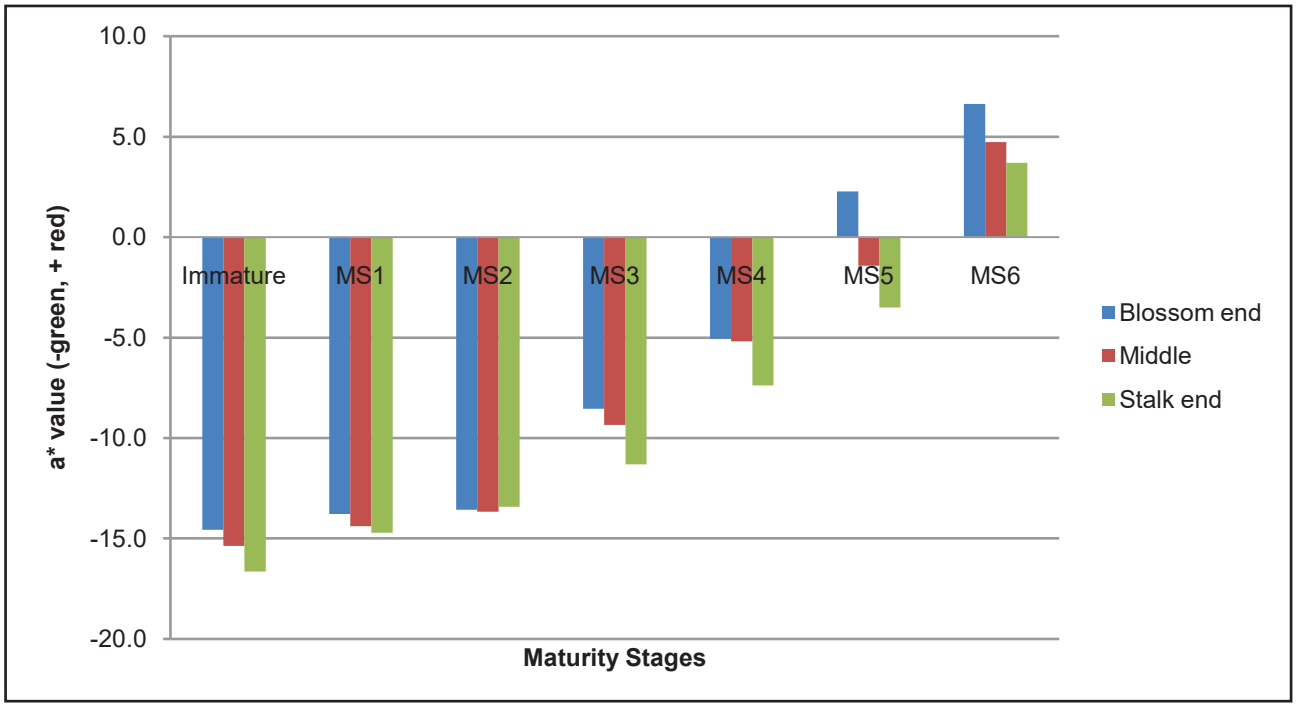

Figure 2: a* value of different maturity stages of Red Lady variety of papaya, 2020

4. b* value

Skin b* values range from 14.8 in green fruit to 48.6 at MS6. Skin b* value varies an average of 15 in green fruit, 16.9 in MS1, 24.67 in MS2, 26.17 in MS3, 32.03 in MS4, 36.03 in MS5 and 38.1 in MS6 indicating increase in b* value with advancement of maturity stages of Red lady variety (figure 3). This makes the b* value useful in differentiating the maturity stages from immature fruit. However, Santamaría, 2009 found b* value useful in differentiating the early maturity stages from immature fruit in Maradol papaya. The result of the increase on the values of parameters a*, b* and L* was similar to the results obtained in studies performed by Ornelas-Paz et al., (2008), where L* is correlated with the carotenoid content in the mesocarp of "Manila" mango.

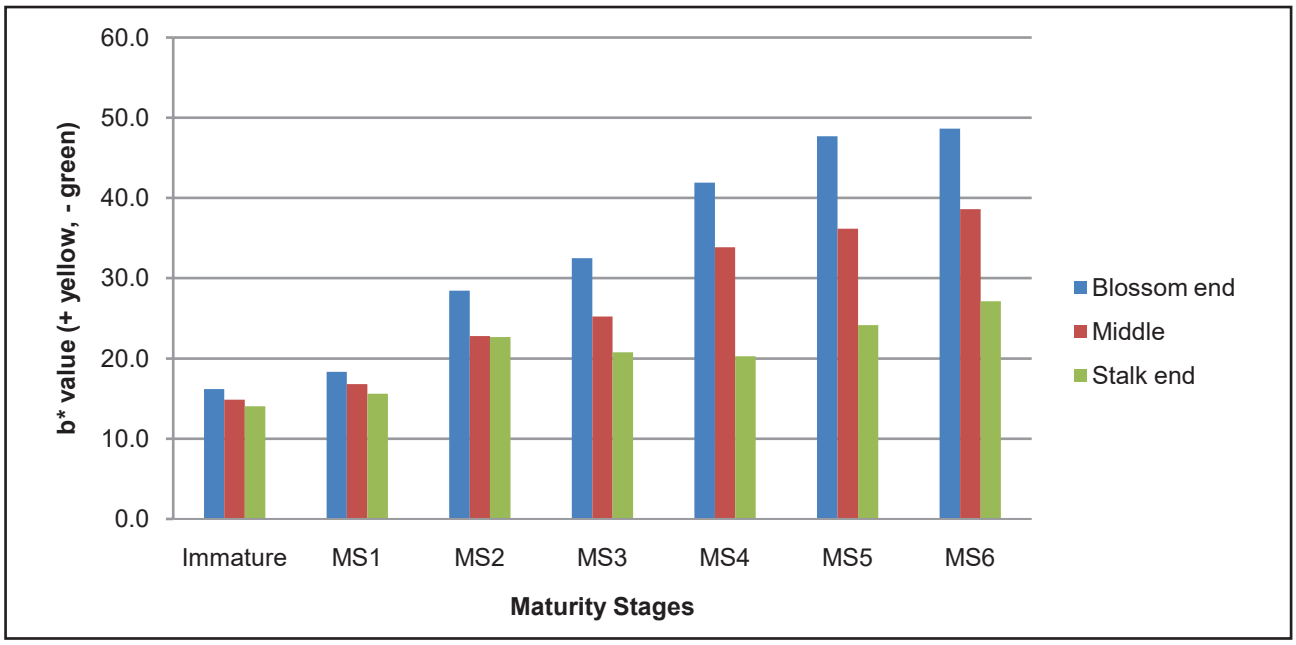

Figure 3: b* value of different maturity stages of Red Lady variety of papaya, 2020

*4. Skin color [(L*a*)/b*] value*

Color values of papaya fruit peel were studied in terms of L*, a*, b*. Highest L*, a*, and b* values were observed at later stage while the initial stage has shown minimum values of L*, a* and b*. Skin color value remain negative in immature stage up to MS5 stage while the value remains positive for MS6. This might be due to the presence of green traces on outer surfaces till MS5 while the skin color for MS6 is fully yellow-reddish.

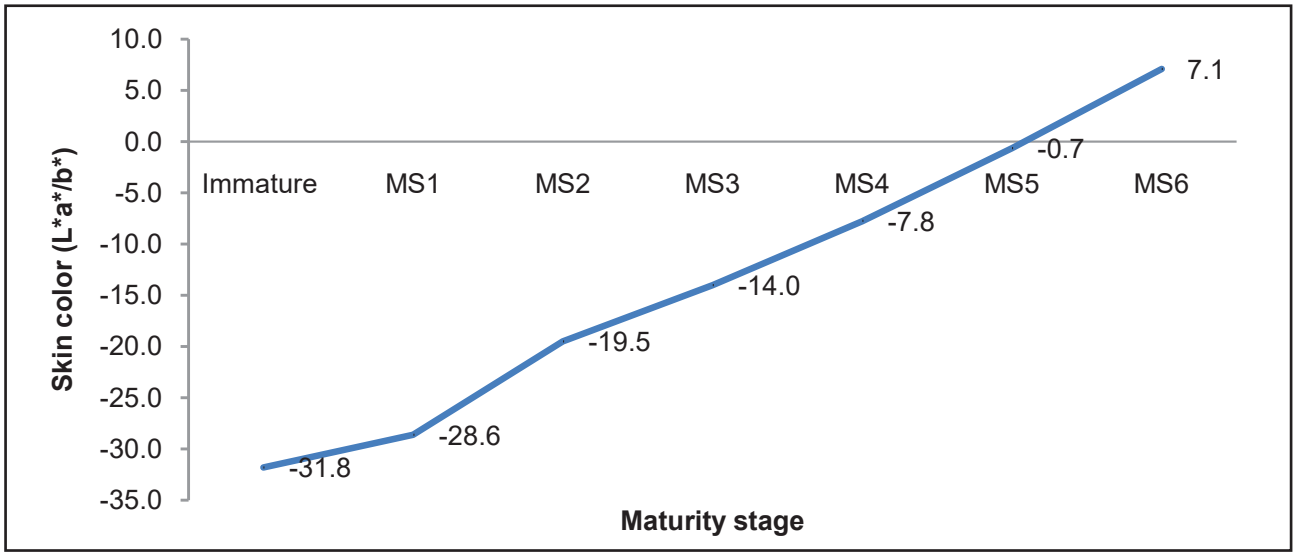

Figure 4: Skin color [(L*a*)/b*] value of different maturity stages of Red Lady variety of papaya, 2020

5. TSS

Maturity stage had a significant effect on the TSS. TSS in Red Lady increased rapidly between green/immature fruit and MS1 and then increased more gradually to stages MS5 and MS6, reaching values of up to 12.48 °Brix as in figure 5. Camara et al., (1993) and Schweiggert et al. (2011) observed similar gradual increase in TSS content during papaya ripening. Other studies on the TSS content of fully ripe papaya were 10° to 11.2°Brix for cv. Solo 8 (Yao et al., 2014), 10.5° to 11.5°Brix for cv. Pococi (Schweiggert et al., 2011) and 9° to 13°Brix for Bangladeshi (Zaman et al., 2006).

6. Firmness

The rate of firmness loss was also affected by the maturity stage at harvest. Fruit harvested at a more advanced maturity stage had lower pulp firmness compared to that harvested at an earlier maturity stage (figure 5). Similar kinds

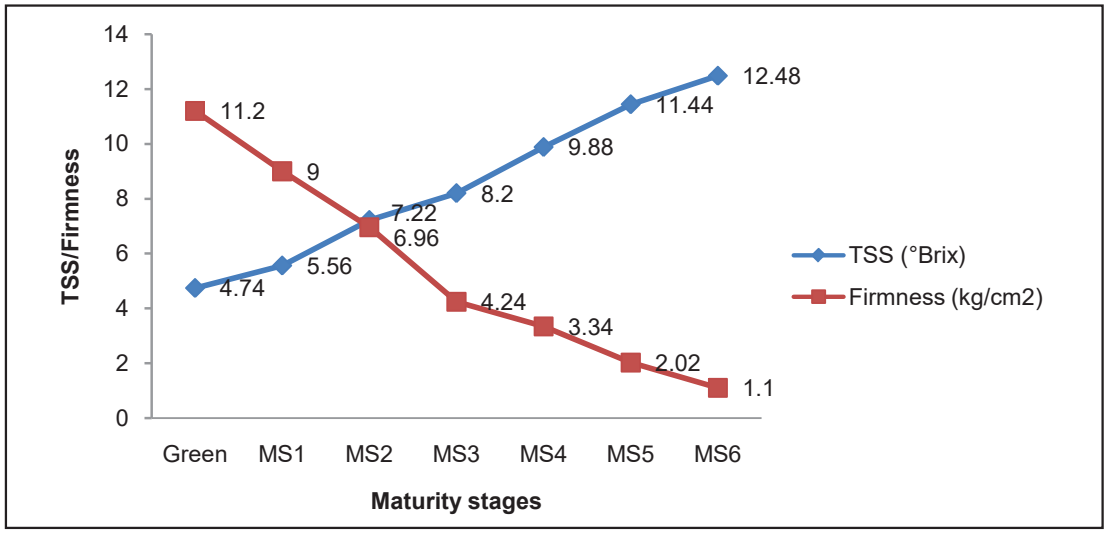

Figure 5: TSS and Firmness of different stages of Red Lady variety of papaya, 2020

of patterns were observed by Bron et. al, 2006 on golden papaya. In green fruit, pulp firmness was 11.2 kg/cm2 and then decreased slightly. Firmness decreased extremely almost 3 fold between stages MS2 and MS3. Furthermore, the decreasing trend of firmness continues with enhancement in the maturity stage but less drastic decreases occurred in the later maturity stages (Figure 5).

Discussion

Change in color is widely used as a visual maturity index in many fruits (Reid, 2002). Visual characteristics as well as L*, a*, and b* value were used in assessing the maturity indices. Color intensity generally increases with an increase in maturity stage up to a certain point involving loss of chlorophyll, synthesis of new pigments such as carotenoids, and unmasking of other pigments previously formed during fruit development (Aked, 2000; Ferrer et al., 2005). The initial changes in Red Lady papaya fruit appearance observed in the present study were caused by increases in the L* (luminosity) and b* (yellow) values, and not by loss of green color, since the negative skin a* (green) values remained relatively unchanged in green fruit and stage 1 and 2 fruit (Figure 3) as in maradol papaya identified by Santamaria et al., 2009. As maturity progressed, the lightness of the peel was increased parallelly due to a decrease in chlorophyll content and an increase in carotenoid content (Miller et al., 1940). An increase in b* value shows the increase in yellowness in the peel. This makes the b* value useful in differentiating the maturity stages from immature fruit. However, Santamaría, 2009 found b* value useful in differentiating the early maturity stages from immature fruit in Maradol papaya.

In the presented results, pulp firmness continued to decrease. Paull et al., (1999) observed an increase in solubilization of pectin and hemicelluloses with a firmness loss during the ripening of papaya. Similar patterns in firmness loss were observed in papaya cultivars with respect to our study. According to the color, firmness, and TSS values observed in the present study, certain value ranges indicate the most appropriate harvest times of Red Lady papaya for different markets and can aid in quality control.

Conclusion

Red lady papaya fruit shows a different ripening pattern from other varieties and specific maturity indices need to be developed as quality standards for proper harvesting. Six maturity stages are proposed for the Red Lady variety and of these, MS1 can be used as an indicator of physiological maturity stage, MS2 and MS3 can be used as a harvest index for distant market, and MS4 and MS5 can be used as a harvest index for nearby local markets while MS6 for instant consumption and processing. Fruit skin color is a good indicator for maturity while TSS and firmness values can be used as quality standards.

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